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(54) Receiver with audio mute switch controlled by field strength analyzer

(57) In a receiver (100), a receiver unit (110) demodulates a radio frequency (RF) signal into an audio signal (V_{AUDIO}) and provides a strength signal (V_{SSI}). The strength signal has a magnitude proportional to the field strength of the RF signal. A mute switch (120) selectively forwards the audio signal to a speaker (130). An analyzer (140) identifies a first event when the change rate of the magnitude of the strength signal is larger than a predetermined threshold change rate and identifies a second event when the magnitude of the strength signal goes below a predetermined threshold signal. The mute switch opens when both events occur simultaneously and thereby prevents the speaker from outputting unwanted demodulator noise.

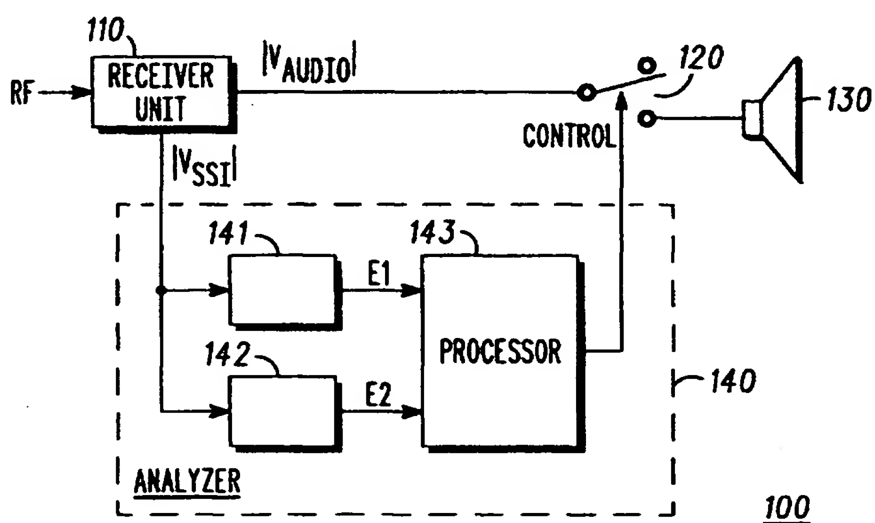

FIG. 2

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Description

Field of the Invention

[0001] The present invention generally relates to radio receivers, and particularly, to receivers having a mute function.

Background of the Invention

[0002] Radio receivers that demodulate radio frequency (RF) signals (e.g., frequency modulation (FM)) to audio signals (or data signals) are conveniently associated with squelch circuits to suppress unwanted demodulator noise by monitoring the audio signal and selectively closing and opening a mute switch in the audio path to the speaker.

[0003] FIG. 1 illustrates simplified time diagram 10 of the audio signal before (11,12) and behind (11, 12', 12") the mute switch, indications of the presence 13 or absence 14 of a carrier in the RF signal, and indications of the switch positions closed 15 and open 16 of the mute switch.

[0004] As long as until t_1 the carrier is present 13, the audio signal before and behind the closed switch is a useful signal, e.g., voice, music, or data (hereinafter collectively "voice") as indicated by traces 11 and 11', respectively. When at t_1 the carrier becomes absent 14, the audio signal becomes noise 12. Since the switch is still closed, the speaker outputs noise burst 12' ("noise tail"). Often, noise burst 12' has a signal magnitude that is, in average over the time, higher (e.g., 1.5 times) that the average magnitude of voice 11'.

[0005] After detecting the noise, the squelch circuit opens the switch at t_2. Hence, speaker outputs noise burst 12' followed by substantial silence 12". For correctly detecting noise 12, the squelch circuit constantly integrates the audio signal. The burst duration T_{BURST} from t_1 to t_2 (between 50 and 60 or more milli seconds) is related to integration constants that are multiple (e.g., 1000) of the shortest periods of voice 11 and noise 12 (e.g., ≥ 0.1 milli second for a ≤ 10 kHz signal).

Detailed Description of the Drawings

[0006]

FIG. 1 illustrates a simplified time diagram of an audio signal before and behind a mute switch, indications of the presence or absence of an RF carrier, and indications of the switch positions;

FIG. 2 illustrates a simplified block diagram of a receiver according to a first embodiment of the present invention;

FIG. 3 illustrates a simplified block diagram of a receiver according to a second embodiment of the present invention;

FIG. 4 illustrates a simplified a simplified block diagram of a microprocessor controlled receiver in a third embodiment of the present invention;

FIG. 5 illustrates a simplified time diagram of a strength signal used in the embodiments of the invention; and

FIG. 6 illustrates a simplified time diagram in comparison to the time diagram of FIG. 1.

Detailed Description of the Embodiments

[0007] FIG. 2 illustrates a simplified block diagram of receiver 100 according to a first embodiment of the present invention. Receiver 100 comprises receiver unit 110, mute switch 120, electro-acoustic transducer 130 (e.g., speaker), and analyzer 140 (dashed frame). Preferably, analyzer 140 is implemented with event detectors 141 and 142 as well as AND-gate 143. The radio frequency (RF) signal arrives at receiver unit 110 via an antenna (not shown) or via further RF circuitry.

[0008] Receiver unit 110 demodulates the radio frequency (RF) signal into audio signal $|V_{AUDIO}|$ and provides a strength signal $|V_{SSI}|$ that is, preferably, a Signal Strength Indicator (SSI). A time diagram for $|V_{SSI}|$ is explained in connection with FIG. 5.

[0009] Mute switch 120 selectively forwards the audio signal to analyzer 140 which identifies first (1) and second (2) events and causes mute switch 120 to open when both events (1)(2) occur simultaneously.

[0010] The first event (1) occurs when the change rate of the magnitude of the strength signal is larger than a predetermined threshold change rate (e.g. expressed in milli volt per milli second), that is

$$|dV_{SSI}/dt| > |\Delta V/\Delta T| \qquad (1)$$

The symbol || indicates absolute values.

[0011] The second event (2) occurs when the magnitude of the strength signal ($|V_{SSI}|$) goes below a predetermined threshold signal (e.g., expressed in milli volt), that is

$$|V_{SSI}| \leq |V_{LIMIT}|, \qquad (2)$$

[0012] In analyzer 140, detectors 141 and 142 issue first (E1) and second (E2) event signals (e.g., logical "1" for occurrence, "0" for non-occurrence), respectively. AND-gate 143 conjunctively relates event signals E1 and E2 to control signal CONTROL for mute switch 120, that is

$$\text{CONTROL} = \text{E1 AND E2}. \qquad (3)$$

[0013] For example, mute switch 120 opens if CONTROL toggles to logical "1" and closes if CONTROL toggles to logical "0". Persons of skill in the art can modify the logic, for example, by using Morgan's rules, without departing from the scope of the present invention.

[0014] Preferably, receiver 100 provides the strength signal $|V_{SSI}|$ by rectifying the RF signal (e.g., half wave rectification). Hence, the DC part of $|V_{SSI}|$ is proportional to the field strength of the RF signal. Rectifying the RF signal with an averaging time constant τ_{SSI} between 10 to 10.000 signal periods is convenient.

[0015] Strength signal $|V_{SSI}|$ can be an analog signal; having it represented as a voltage is convenient for explanation, but not essential for the present invention, it can also be represented as a current. The strength signal $|V_{SSI}|$ can also be represented in a digital form.

[0016] In an SSI estimate, receiver unit 110 measures the level of the received signal on the desired RF frequency. This measurement provides a summation of signal levels including the desired information signal, the co-channel interference, and the noise on the desired RF channel.

[0017] For FM receivers, it is convenient if receiver unit 110 derives $|V_{SSI}|$ from an RF signal being the intermediate frequency (IF) signal, for example, in the 10.7 mega hertz (MHz) band.

[0018] FIG. 3 illustrates a simplified block diagram of receiver 200 according to a second embodiment of the present invention. In FIGS. 2-3, reference numbers 100/200, 110/210, 120/220, 130/230, 140/240, 141/241, 142/242, 143/243, and symbols E1, E2, $|V_{SSI}|$, $|V_{AUDIO}|$ and RF stand for analogous components or signals. Preferably, receiver 200 further comprises delay unit 250, OR-gate 270 and audio squelch detector 260.

[0019] Delay unit 250 keeps mute switch 220 opened for a predetermined mute time interval T_{MUTE} after analyser 240 has detected the removal of the carrier signal from the RF signal. Preferably, T_{MUTE} is longer than a conventional burst duration T_{BURST} (cf. FIG. 1). In other words, delay unit 250 holds control signal CONTROL (AND-gate 240) in turn-off position (e.g., logical "1") for a predetermined mute time interval (T_{MUTE}).

[0020] Audio squelch detector 260 monitors audio signal $|V_{AUDIO}|$. Operating as in a conventional squelch circuit, detector 260 provides a further mute signal M to switch 220 (via OR-gate 270). OR-gate 270 combines signal M with control signal CONTROL so that the signal CONTROL' acting on switch 220 is obtained as

$$\text{CONTROL'} = \text{CONTROL OR M} \qquad (4)$$

[0021] FIG. 4 illustrates a simplified a simplified block diagram of a microprocessor controlled receiver 300 in a third embodiment of the present invention. In FIGS. 2-4, reference numbers 100/200/300, 110/210/310 (receiver unit), 120/220/320 (switch), 130/230/330 (speaker) stand for analogous components. Receiver 300 further comprises microprocessor 380 implementing the functions of analyzer 140/240 with event detectors 141/241, 142/242, AND-gate 143/243 (cf. FIG. 2), and optionally, delay unit 250, OR-gate 270 and audio squelch detector 260 (cf. FIG. 3). As indicated by analog-to-digital converters (ADCs) 381 and 382, processor 380 receives representations of $|V_{SSI}|$ and $|V_{AUDIO}|$, respectively, in digital form. Optionally, microprocessor 380 is a digital signal processor (DSP)

[0022] FIG. 5 illustrates a simplified time diagram of a strength signal $|V_{SSI}|$ used in the embodiments of the invention. While $|V_{SSI}|$ has convenient magnitudes in the range between 0.5 and 2 volt as indicated on the ordinate axis; $|\Delta V/\Delta T|$ has convenient values between 1 volt per second (for normal signal strength change while receiving a carrier) and 10.000 volt per second (when receiving comes to an end) as indicated by dashed-point line 20. However, other values can also be used. Line 25 in parallel to the abscissa axis indicates the predetermined threshold signal $|V_{LIMIT}|$. Bold line 21 indicates strength signal $|V_{SSI}|$ complying with both event conditions (1) and (2); dashed line 22 indicates strength signal $|V_{SSI}|$ not complying with any of the conditions.

[0023] FIG. 6 illustrates a simplified time diagram in comparison to the time diagram of FIG. 1. Reference numbers are as in FIG. 1. Additionally, FIG. 6 illustrates event signals E1 and E2 (cf. FIGS. 2-3) and signal CONTROL (cf. relation (3)). It is an advantage of the present invention that T_{BURST} is shorter than for the prior art. As mentioned above, this is accomplished by primarily monitoring $|V_{SSI}|$ instead of monitoring $|V_{AUDIO}|$ only.

Claims

1. A receiver (100) comprising:

   a receiver unit (110) to demodulate a radio frequency (RF) signal into an audio signal (V_{AUDIO}) and to provide a strength signal (SSI) that has a magnitude proportional to the field strength of said RF signal;
   a mute switch (120) to selectively forward said audio signal to an electro-acoustic transducer (130);
   an analyzer (140) to identify a first event when the change rate of the magnitude of the strength signal is larger than a predetermined threshold change rate, to identify a second event when the magnitude of the strength signal goes below a predetermined threshold signal, and to open said mute switch when said first and second events occur simultaneously.

2. The receiver of claim 1, wherein said receiver unit provides said strength signal by rectifying said RF signal.

3. The receiver of claim 2, wherein said receiver unit provides said strength signal as a Relative Signal Strength Indicator (SSI) signal.

4. The receiver of claim 3, wherein said SSI signal is a voltage signal or a current signal.

5. The receiver of claim 1, wherein the RF signal is an intermediate frequency (IF) signal.

6. The receiver of claim 1 keeping said mute switch opened for a predetermined mute time interval (T_{MUTE}).

7. The receiver of claim 1, wherein said analyzer comprises a first event detector (141) and a second event detector (142) to issue first and second event signals, respectively, and comprises a gate (143) to conjunctively relate said first and second event signals to a control signal (CONTROL) for said mute switch.

8. The receiver of claim 7, further comprising a delay unit (250) to hold said control signal in turn-off position for a predetermined mute time interval (T_{MUTE}).

9. The receiver of claim 9 further comprising an audio squelch detector (260) that monitors said audio signal and provides a further mute signal to said switch.

10. The receiver of claim 10 further comprising an OR-gate (270) to combine said further mute signal with said control signal.

11. The receiver of claim 1 wherein said analyzer is implemented by a microprocessor.

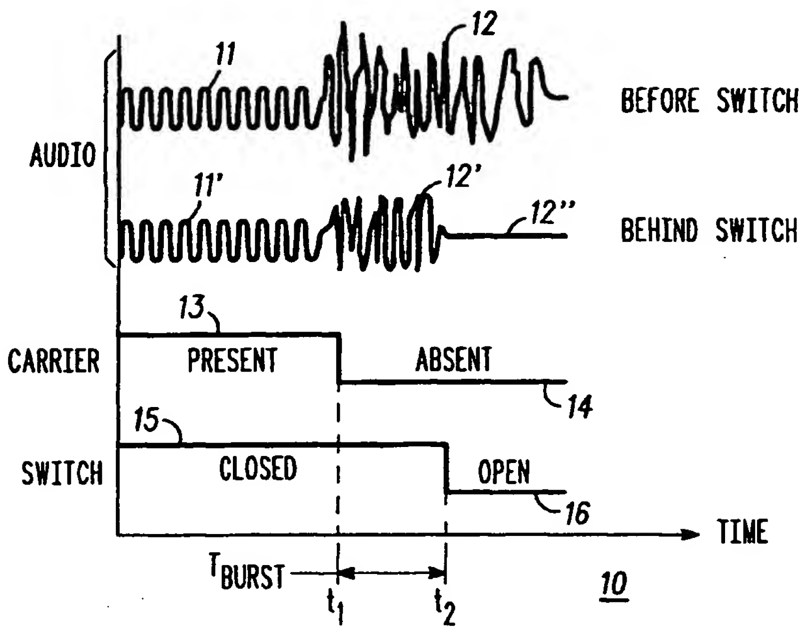
11
12
AUDIO
BEFORE SWITCH
11'
12'
12"
BEHIND SWITCH
13
CARRIER
PRESENT
ABSENT
14
15
SWITCH
CLOSED
OPEN
16
TIME
TBURST
t1
t2
10

FIG. 1

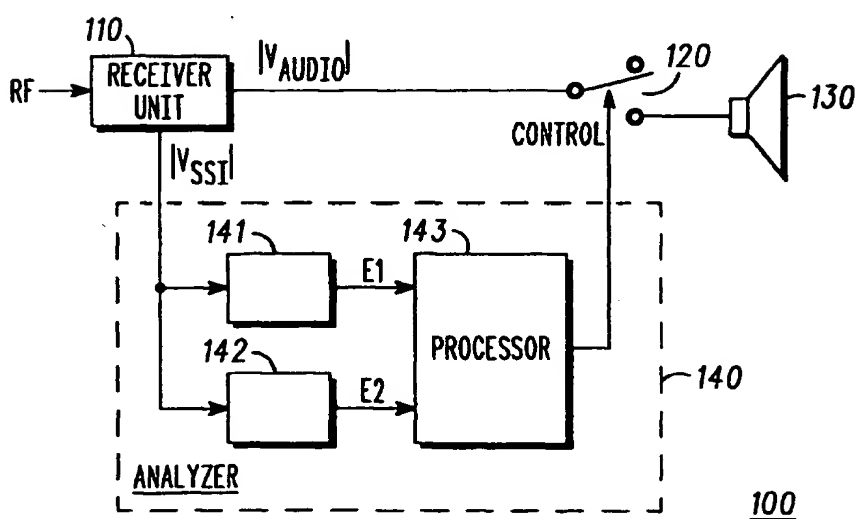
110
RF
RECEIVER UNIT
|VAUDIO|
120
130
CONTROL
|VSSI|
141
143
E1
PROCESSOR
142
E2
140
ANALYZER
100

FIG. 2

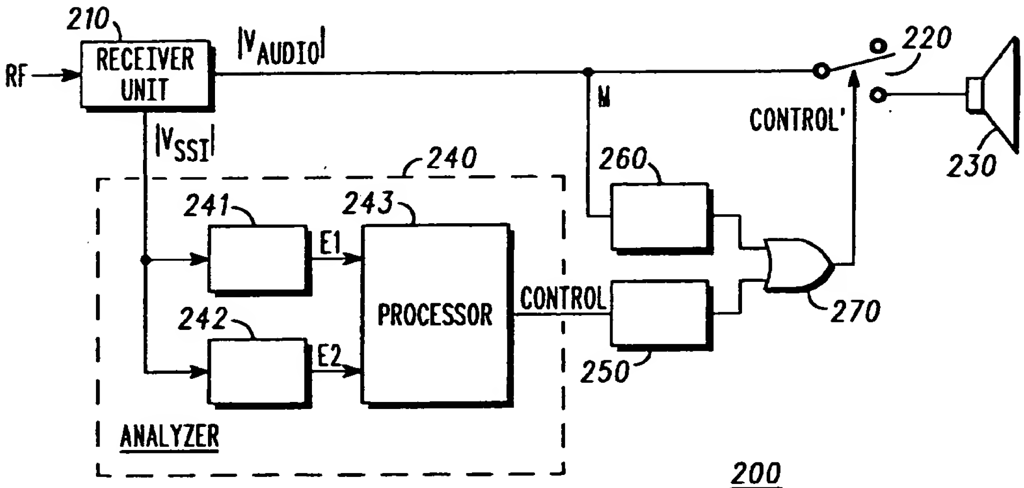
210
RF
RECEIVER UNIT
|V AUDIO|
|V SSI|
220
230
M
CONTROL'
240
260
241
243
E1
PROCESSOR
CONTROL
242
E2
270
250
ANALYZER
200

FIG. 3

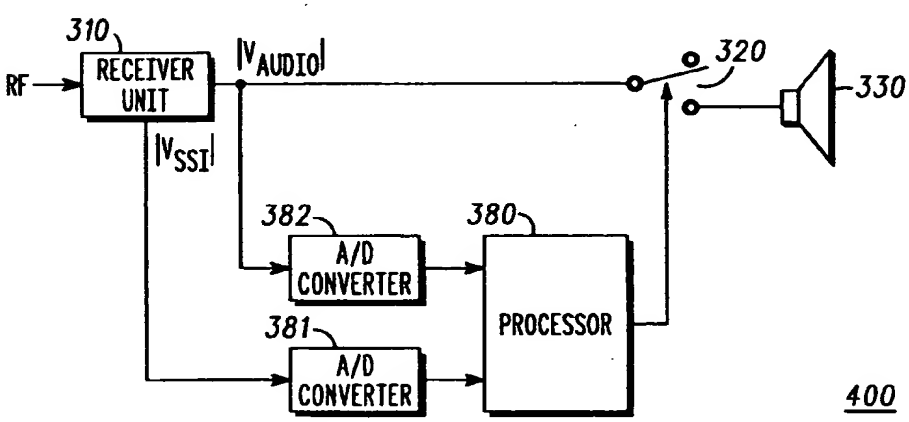
310
RF
RECEIVER UNIT
|V AUDIO|
|V SSI|
320
330
382
A/D CONVERTER
380
PROCESSOR
381
A/D CONVERTER
400

FIG. 4

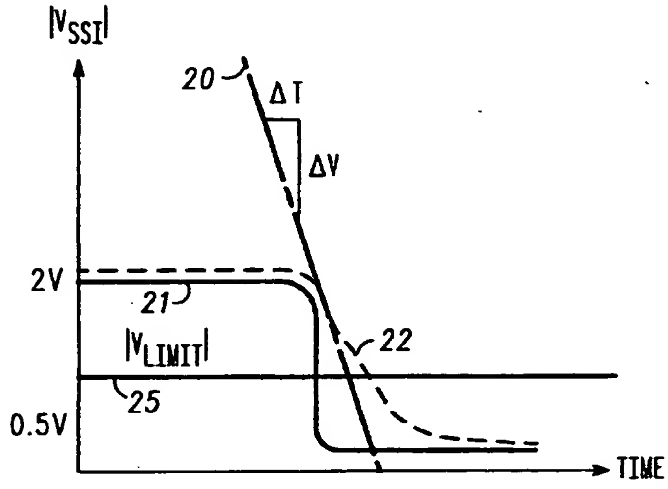
|VSSI|
20
ΔT
ΔV
2V
21
|VLIMIT|
22
25
0.5V
TIME

FIG. 5

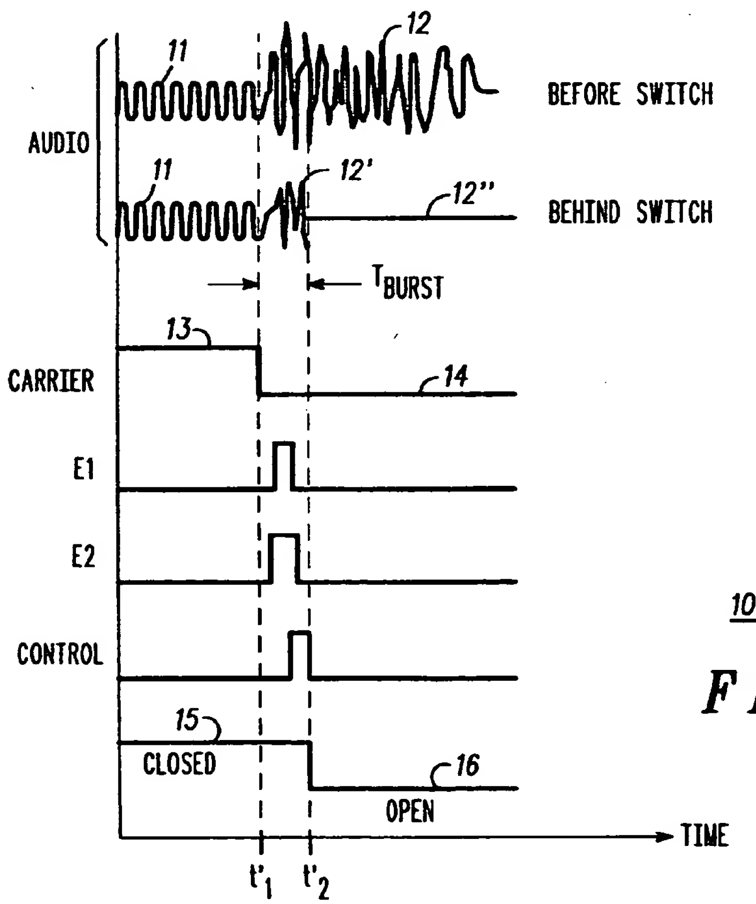
11
12
BEFORE SWITCH
AUDIO
11
12'
12"
BEHIND SWITCH
TBURST
13
CARRIER
14
E1
E2
CONTROL
15
CLOSED
16
OPEN
TIME
t'1
t'2
10

FIG. 6

European Patent Office

EUROPEAN SEARCH REPORT

Application Number
EP 00 10 7543

DOCUMENTS CONSIDERED TO BE RELEVANT

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A	US 4 893 349 A (EASTMOND BRUCE C ET AL) 9 January 1990 (1990-01-09) * column 9, line 12 - column 10, line 7 * * column 13, line 52 - column 14, line 5 * ---	1	
A	PATENT ABSTRACTS OF JAPAN vol. 2000, no. 01, 31 January 2000 (2000-01-31) & JP 11 284529 A (HITACHI DENSHI LTD), 15 October 1999 (1999-10-15) * abstract * ---	1	
A	PATENT ABSTRACTS OF JAPAN vol. 014, no. 444 (E-0982), 21 September 1990 (1990-09-21) & JP 02 174431 A (TOSHIBA CORP;OTHERS: 01), 5 July 1990 (1990-07-05) * abstract * -----	1	TECHNICAL FIELDS SEARCHED (Int.Cl.7) H03G

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	30 August 2000	Blaas, D-L

CATEGORY OF CITED DOCUMENTS

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ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO. EP 00 10 7543

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30-08-2000

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